DOCUMENT RESUME

ED 430 330		EC 307 177
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TITLE	A Head Operated Joystick--Experience with Use.	
PUB DATE	1999-03-00	
NOTE	6p.	
PUB TYPE	Reports - Descriptive (141)	
EDRS PRICE	MF01/PC01 Plus Postage.	
DESCRIPTORS	*Accessibility (for Disabled); *Assistive Devices (for Disabled); *Input Output Devices; *Severe Disabilities; Use Studies	
IDENTIFIERS	*Joysticks	

ABSTRACT

This paper describes the development and evaluation of a low-cost head-operated joystick for computer users with disabilities that prevent them from using a conventional hand-operated computer mouse and/or keyboard. The paper focuses on three issues: first, the style of head movement required by the device; second, whether a head-operated device should work as an absolute positioning device or as a joystick; and, third, the accuracy required by the device. It finds that the device's "nose following" style of head movement is more accepted by users than alternatives; that users also preferred the joystick relative pointing device over absolute positioning devices; and that users did not notice inaccuracies inherent in the device's design, thus allowing production at a lower cost. (DB)

A HEAD OPERATED JOYSTICK - EXPERIENCE WITH USE

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Introduction

Computer users who cannot use a conventional hand-operated computer mouse and/or keyboard, may use a head-operated mouse or joystick in order to control their computer and, by using an on-screen keyboard, to type information. Wireless devices of this kind, where the user's head movements are translated into mouse pointer movements without the need for a direct connection between the user and the machine, have become popular over the past few years. These include Origin Instrument's Head Mouse (ref 1.), Pentke-Romish's Head Master Plus (ref. 2) and Madenta's Tracker (ref. 3). Typically, these devices require the user to wear only a small, reflective pad that is stuck to the user's forehead or glasses. This reflects infrared light that is emitted from a device mounted close to the user's computer monitor. The light reflected from the head-mounted pad is used to determine head orientation, from which appropriate signals are generated to emulate a standard serial mouse.

Although the devices listed above work very well and require the user to wear only the very minimum of equipment on his/her head, they are relatively expensive in the United Kingdom (around £1000). This price limits the availability of head control for some users. Motivated by this, the authors have, for the past four years, been engaged in research to produce a 'low technology' head operated device that can be sold at a much lower price. A variety of approaches have been evaluated. These include using the Earth's gravitational field (ref 4), the Earth's magnetic field (ref. 4) and a system that uses infrared light emitting diodes LEDs to signal head position to a remote photodetecor (ref. 5). The last of these devices has acceptable characteristics and has been developed as a commercial product that costs just less than £200.

This paper is not about the operating principles or the design of this head-operated joystick, that information is presented in reference 5. Rather, this paper focuses on the lessons that we have learnt from the development and evaluation of this device. These should be of interest to those that use, specify or develop devices of this sort. Specifically, we focus on three issues. Firstly, the style of head movement required by the device. Secondly,

whether a head operated device should work as an absolute positioning device or as a joystick, and, thirdly, the accuracy required by the device.

Head Movement

Control of the mouse pointer's movement in the horizontal direction (i.e. left-right movement) is dependent on the technology used to implement the mouse. Some systems, especially those that use gravitational or magnetic field to determine head position, require users to bend their neck so that their ears are moved toward their shoulders to move the mouse pointer left or right. Our earlier head-operated joysticks worked in this way. Many of the 30 users who trialed these devices found this movement unnatural, uncomfortable and tiring and indeed we abandoned work on our earlier devices in response to this feedback.

Almost all of the most sophisticated systems, including our own infrared-based head-operated joystick, use a much more natural form of head motion. To move the mouse to the left or right the user rotates his/her head left <-> right with the neck kept straight. It is the same motion as people use to signify no by shaking their head. This motion is more natural and much less tiring and seems to be greatly preferred by users. It is also conceptually more satisfying and consistent, because the mouse pointer allows follows the direction of the user's nose.

It is important to recognise that not all head-operated mice or joysticks employ this 'nose following' pattern. When purchasing another type of device one should check that the user can use it comfortably for reasonable periods of time.

Style of Interaction: Joystick vs. absolute positioning

A head-operated device can be designed to work in two ways. Firstly, it can be configured as an absolute pointing device, which will work in a similar manner to a graphics tablet. This means that each orientation of the user's head corresponds to a specific mouse pointer position on the screen. If the mouse pointer is in the middle of the screen and the user wishes to select an icon in the top left of the screen, the user moves his/her head in that direction. When the pointer reaches the icon, the user keeps his/her head in that position until the selection is made. Conceptually this mode of operation is very attractive, because, if the system is set up correctly, the mouse pointer's position corresponds with that of the user's eyes.

The second style of interaction is to configure the device as a relative pointing device. This style of interaction is very similar to a hand-operated joystick. Like a hand-operated joystick there is a neutral position - in this case a central head position that we refer to as the 'deadband' - which, when the head is held in this position, results in no mouse pointer movement. To move the mouse pointer, the user moves his/her head out of the deadband in the desired direction and holds his/her head in this position until the mouse pointer is in the desired position. At this point the user returns his/her head to the deadband.

There are two decisions to be made about the way in which a joystick device works. The first concerns the number of distinct directions that the joystick supports. The minimum number is 4 (up, down, left, right), the maximum number is effectively unlimited. In our device we chose to have 8 directions. We have found through experience that this is sufficient for accurate pointer control, although some users use the diagonal direction only rarely. For example, to move from the centre of the screen to the top left, may be accomplished by moving one's head up and to the left simultaneously. However, some users split this into a two-part operation, moving firstly to the left and then upward or vice versa.

The second issue concerns the speed of the mouse pointer after the user has moved his/her head out of the deadband area. The authors' joystick has two speeds. Gross head movements correspond to relatively fast movement of the mouse pointer. With the head just outside the deadband the mouse pointer moves much slower, allowing the user fine control over positioning of the mouse pointer. The two-speed configuration has been arrived at empirically. The size of the deadband and the 'fine control area' and the two mouse speeds can be configured to match a user's requirements.

Mice and joysticks present the user with somewhat different operational characteristics. One might expect that an absolute positioning device would result in quicker movement to the desired position but require good head control skills. The joystick-style device would give slower selection but, because the mouse pointer does not move when the head is held in the deadband, the system requires less precise control of head position. Of course, the important issue is what do users prefer?

In an attempt to answer this question a relatively informal comparative trial was held between a commercially available head-operated mouse (absolute positioning style) and the authors' head-operated joystick. Nine disabled users firstly used the mouse to interact with a computer system for about an hour. The same users were then given

the authors' joystick to use in the same way. All nine users indicated that they preferred the joystick-style device because it required less accurate control of the head.

It is important, therefore, to consider the style of interaction when specifying and configuring a head-operated device. Some commercially available devices (notably the Tracker (ref. 3)), can be configured to work in either mode, others are restricted to work in one mode. For instance the author's device is can only be used as a joystick for general computer interaction.

Finally, from a system design and implementation point of view, joystick-style devices require less accuracy than absolute positioning style devices. This is because the system needs only to determine whether the head is moved outside the deadband and in which direction, it does not have to precisely determine the position of the head. The requirement for lower accuracy lends itself to lower technology solution, which, in turn, can lead to lower cost devices.

Accuracy

Head-operated mice and joysticks work by determining the rotation of a user's head (in two axes) with respect to a fixed point. In the case of mice, the system needs to determine the exact head position. In the case of joysticks, one needs to determine whether the head is in the deadband or not, and if not, in which direction it has moved. In addition, the authors' joystick needs to determine whether the head is in the 'fine control area' corresponding to slow mouse pointer movement, or outside this area corresponding to faster mouse movement.

Despite the fact that the joystick-style of operation requires less accuracy in determining the degree of head rotation, it is still important that the device behaves in a consistent manner. In the design of our joystick we made every effort to develop a system that would accurately measure the relative rotation of the head. However, for the device to be totally accurate, we require that infrared LEDs used to signal between the head-mounted equipment and the interface adjacent to the computer's monitor have uniform irradiation patterns and accurate alignment (ref 5). In practice, we find that the irradiation pattern of LEDs is highly variable. Not only do they vary greatly from device to device, but also a given device may have an irradiation pattern that is unsymmetrical. Thus, our device is incapable of accurately and consistently measuring the relative rotation between the user's head and computer monitor. Because there is considerable variation between LEDs, each of our joysticks has unique operational

characteristics. This might seem to pose a great problem. However, in practice, the users are unaware of the inaccuracies. It is thought that this is as a result of the closed feedback loop of the users seeing the mouse pointer move on the screen as they move their head. They unconsciously adapt their head movements to correspond to the movement of the pointer. They do this without realising that they are compensating for an imperfect device, and so adapt their use without even realising that they are doing so. This means that, in the authors' device, the variation in component performance and the alignment of the LEDs is not critical. Concequently a less accurate device can be developed at lower cost.

It is not clear what implication this has on the design of head-operated mice. The authors' joystick can be configured to operate as an absolute positioning device, however it is not accurate enough to be used reliably in the same way as the commercially available head operated mice. At best it can be used at 256x256 resolution and more typically at 64 x 64 resolution.

Concluding Remarks

In summary the results of our work are: users find 'nose following' devices less tiring to use than those that require neck bending; for many users the joystick style of interaction is preferable to the absolute positioning style; users can tolerate inaccuracies in joystick-style devices in a transparent manner; and because of the reduced requirements for accuracy joystick devices may be produced and marketed at lower cost.

References

(1) orin.com/access/headmouse/index.htm - current at 11/9/98

(2) www.prentrom.com/access/hmaster.html - current at 11/9/98

(3) www.madenta.com/mprod/pnt_a.htm - current at 11/9/98

(4) D. G. Evans, S. Pettitt & P. Blenkhorn, "A Head Operated Joystick", Proceedings of 5th ICCHP, Linz, Austria, pp 85-91, 1996

(5) R. Drew, S. Pettitt, P. Blenkhorn & D. G. Evans, "A Head Operated Joystick Using Infrared", 6th ICCHP, Vienna, Austria and Budapest, Hungary, pp 420-429, 1998

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